Imaging with the HLCO 24” Telescope

Updated 4 February 2019

WARNING!!

The telescope has safety limit switches, but it may still be possible to point the telescope below the horizon if you aren’t paying attention. **Always** be aware where the telescope is pointing and where the instruments and cables are in relation to the mount. The telescope should not be allowed to point below the dome track ring, nor should it be allowed to hit the fork mount!!!

Telescope Characteristics

0.61m f/6.8 Corrected Dall-Kirkham astrograph telescope
4145 mm focal length

CCD Camera Characteristics

Apogee CCD 2048x2048 pixels
Pixel size: 15µm x 15µm
Pixel scale: 0.77 arcsec/pixel
Field of view: 26.3’ x 26.3’
Gain: 2.3 e-/ADU
Readnoise: 11.3 e-
Dark current: 0.068 e-/pixel/s at -25C in Jan
Limiting magnitude reached in 30s
(*Note: tested on the 20-inch)*
U=14.4, B=16.8, V=16.9, Rc=16.5, Ic=15.1

Emergency Contact Info

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(before 9pm, text 404-909-3740)

There is a VOIP telephone in each dome and in the electronics room. Cell phone service is spotty at HLCO, but texts seem to work ok, especially if you connect to GSU WiFi.

Overview

The primary method of controlling this telescope is with ‘MaxIm DL’. This is also the software for controlling the instrument (changing filters, setting exposure times, and so on).

The program 'STI' is also used and controls pointing, parking the telescope, etc.

A third program, ‘Planewave Interface’ (PWI), is used to focus the telescope.

Things to be aware of with this equipment:

Always be sure to plan ahead and give the camera and the dome plenty of time to cool down (as much as possible) and to equilibrate before taking any data, including calibrations. This will involve arriving early and starting the cool down process well before (at least a full hour) you intend to get started for the night.

The camera shutter is an iris and it makes itself known in short exposures. Keep your exposure times longer than 2 seconds if at all possible.

The chip is air cooled and has a noticeable amount of dark current. Plan to obtain a stack of dark frames that match the exposure times of all your science targets.

The primary camera (should be installed for most observations) has a dead column just off the center of the field of view.

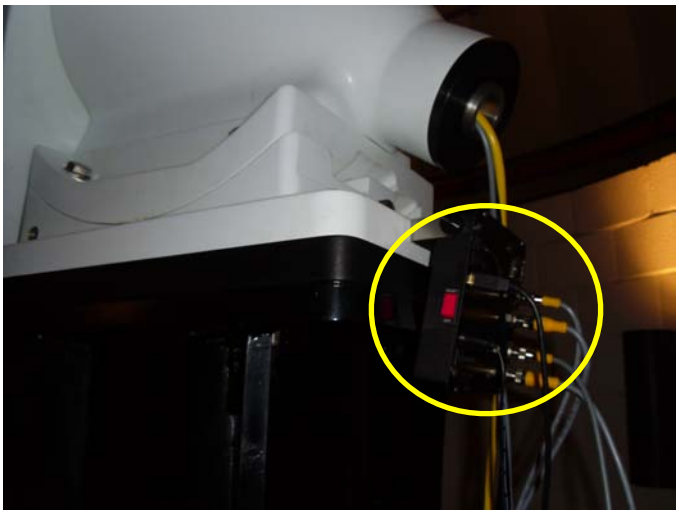
The secondary camera (should only be installed as a backup) suffers from some slight image persistence. A bright star will leave a “ghost” image behind, even after reading out the camera. A reasonable observing strategy would be to intersperse your science targets with dark frames of the same exposure time. If you make sure to dither between science images, then you can median together your darks when you get back home and clip out the high pixels left behind from ghosts. Additionally, you can also intersperse biases to help clear out the residual charge on the chip. You might end up with observation patterns that look like this:

target - bias - dark - dither
target - bias - dark - dither
target - bias - dark - slew to new target

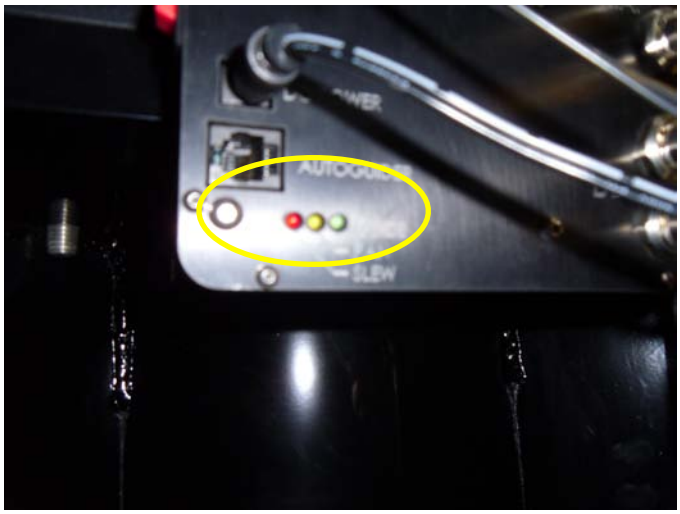
General Telescope Operating procedure:
There are two hand paddles, one controls telescope movement and the other controls the telescope focus motors.

The movement hand paddle has a very simple design and is usually sitting at the base of the telescope. The arrow keys control movement while the center button controls the slew speed: Red -> slew (fast), Yellow -> pan (medium), Green -> guide (slow). These LEDS are found on the black box mounted on the back of the telescope pier.

The focus hand paddle is the one that appears more modern. It is hanging on a peg on the bottom of the telescope. To change focus use the hand paddle and press the up or down arrows



Black box on the back of the telescope pier. Note the red power switch.



Zoom-in of the red, yellow, and green LEDs that show the currently-selected slew speed.

NOTE: The telescope does not stop moving instantaneously. It will continue to move for another 1/2 second or so. Just be patient and let it come to a full and complete stop.

General Dome Operating procedure:

1. The dome has two shutters that open. The top dome shutter is controlled with a large switch with a hand knob on the dome itself (Fig. 1). There is a second switch, however, in the form of a horizontal metal sliding piece that moves left and right. The edge of this sliding piece is circled in yellow in Fig. 1. Put the large switch with the knob in its middle position before sliding the horizontal piece left or right. To open, push the sliding horizontal piece left and then the large switch with the knob will open the shutter when you push it also to the left. Push both switches to the right (horizontal sliding switch first then switch with the large knob second) to close the top dome shutter.
2. Once the top shutter has opened part way, the lower shutter can be opened with the rocker switch (Fig. 2). It will automatically stop when it is fully open.
3. If it is a very warm day (as it is in late spring or in summer) open the dome windows for maximum airflow.
4. Manual rotation of the dome can be done with the red dome switch hanging on the wall (Fig. 3). Make sure that you allow the dome to come to a full and complete stop before attempting to rotate it back the opposite direction (for example, if you overshot the position you wanted).

Fig. 1 - Upper dome shutter switches:
large knob and horizontal sliding metal piece

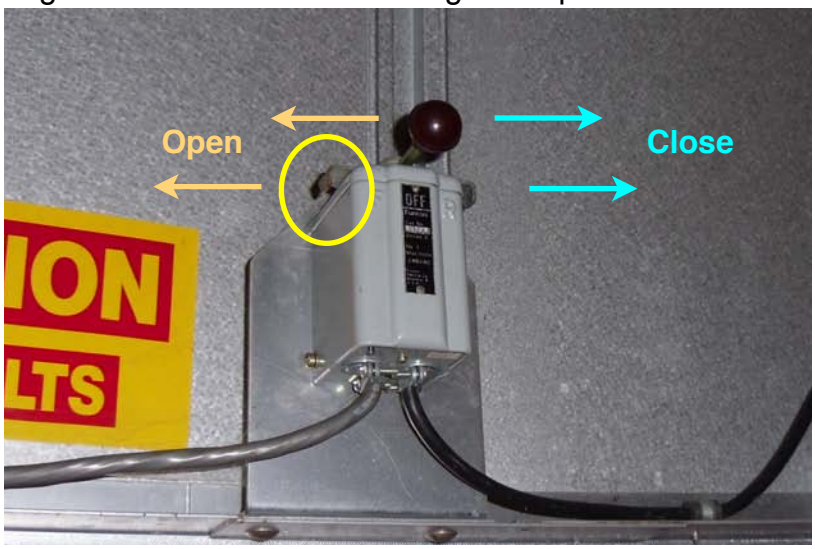


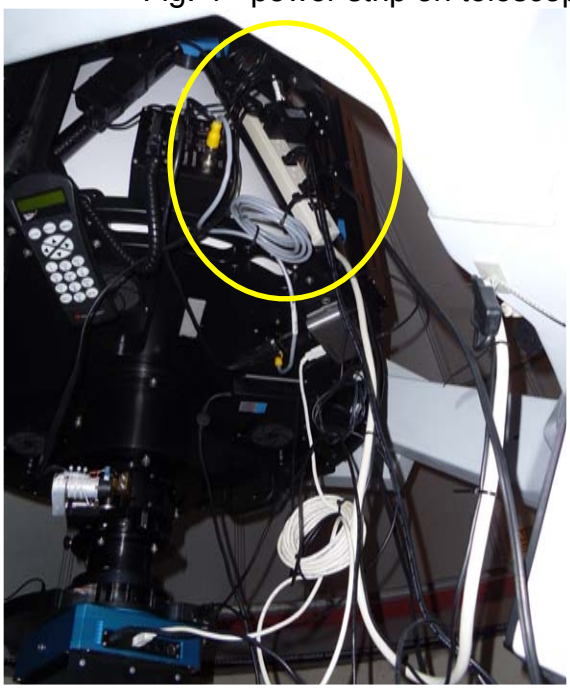
Fig. 2 - Lower dome shutter rocker switch

Fig. 3 - Dome rotation switch

With the red switch on top and facing you, pushing the switch left will cause the dome to rotate to the left, and pushing the switch right will cause the dome to rotate to the right. Bring the switch back to center to stop the dome rotation.

Telescope Start-up Procedure

Fig. 4 - power strip on telescope



1. Plug in and turn on the computer and monitor. If they are already on, restart them.
2. Check the clock time on the computer vs. your cell phone or the official US time website or some other accurate source. If necessary, set the computer clock time manually (sometimes it loses the connection to the internet time and this affects the telescope pointing).
3. Plug in the power cords on the floor at the base of the telescope pier.
4. Turn on the power switch on the black box mounted on the back of the pier (see picture above).
5. Turn on the power switch on the power strip mounted directly to the side of the telescope tube (circled in Fig. 4)

FIRST IMPORTANT NOTE

Be very careful when you are in the STI program window. The controls here set the most basic movements for the telescope and the 'Home' locations and 'Park' locations. Always verify an operation in this window before carrying it out to be sure that you don't overwrite any settings.

6. Back at the computer, open the controls for the mirror covers by double-clicking the *PlaneWave Shutter Control* icon on the desktop.
7. In the *PlaneWave Shutter Control* (Fig. 5) window, press the *Connect* button to connect to the control box, and wait for the program to say you are connected. Then press *Open* and wait for all four mirror cover petals to open.
8. Minimize the *PlaneWave Shutter Control* window to make room (DO NOT close the program, the connection needs to be kept up and running).
9. Start the STI program by double-clicking on the *SiTechExe* icon. Make sure you are viewing the *Scope* side tab, then click *UnPrk* to get the telescope ready to be moved (outlined in blue in Fig. 6). This will turn on tracking, which we do not yet want. Click *STOP* to turn off tracking for now.

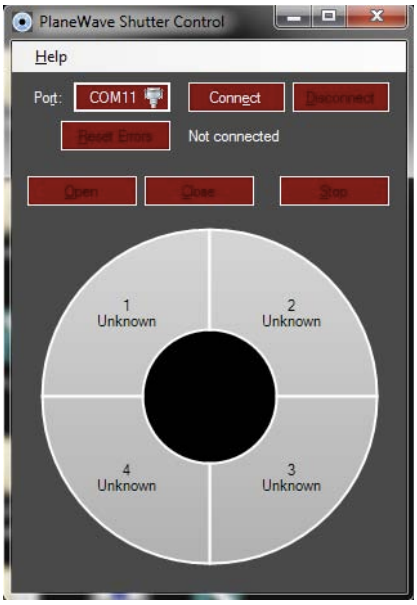
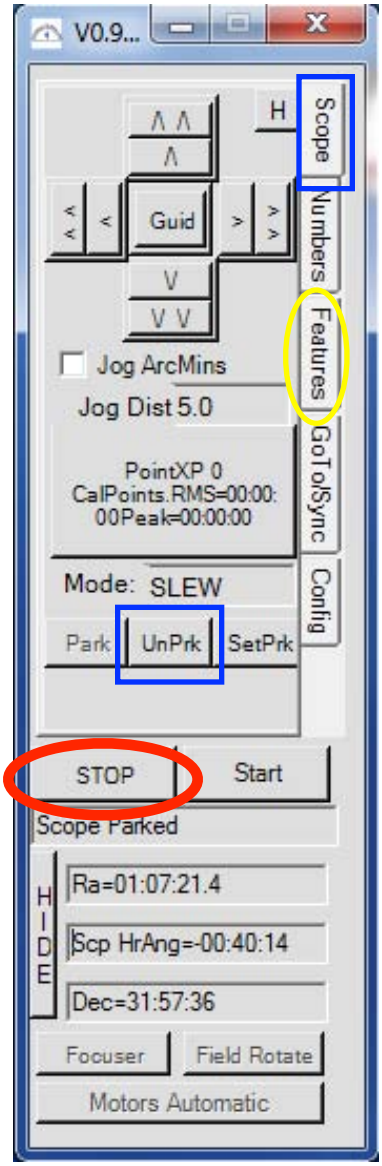


Fig. 5 - PlaneWave Shutter Control program for the primary mirror covers



SECOND IMPORTANT NOTE

Before you ever start moving the telescope with the computer, be sure you know where the **STOP** button is located.

There is one circled in red in the STI window (Fig. 6). Remind yourself where the **STOP** button is at the beginning of every observing run and be sure that this window is always accessible throughout your observing run.

Clicking the **STOP** button will stop all telescope movement, including sidereal tracking, so you may need to restart tracking if you use the **STOP** button while observing.

Fig. 6 - STI window: **STOP** button --- make sure you always know where it is

Also note the movement buttons at the top of the STI window; if the telescope movement hand paddle is misbehaving, you can move the telescope with these buttons

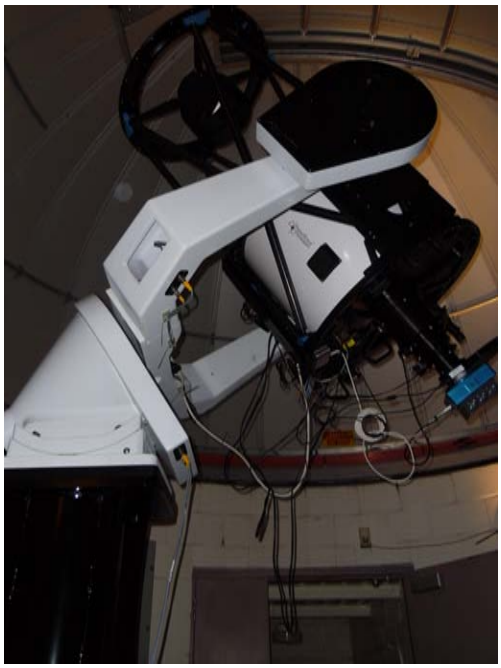


Fig. 7 - Telescope in the "Home" position, pointing at the celestial equator

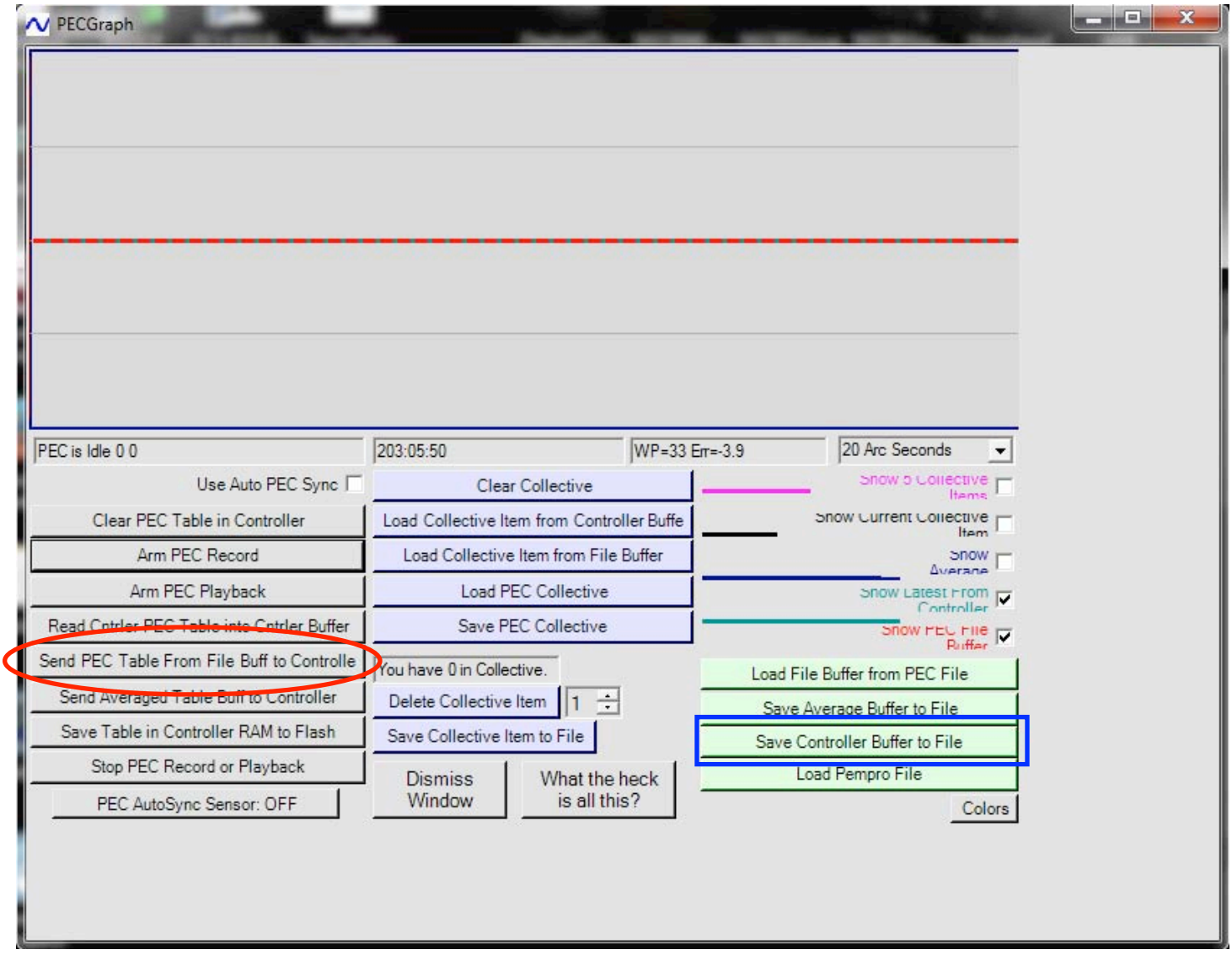
This picture was taken from the computer desk (note the dome door at the bottom of the page).

"Park" position should be vertical, pointing straight up at the zenith (like the front page image).

Every time you "home" or "park" the telescope, make sure you are ready to hit the **STOP** button in case the telescope tries to move somewhere other than these two locations.

10. You will need to manually load the pointing model for the telescope to help it remember how to find objects in the sky. In the STI program window, click the *Features* side tab, then click *PEC Control* button.
11. A window will appear (see Fig. 8). In the bottom right, click on the *Load Pempro File* button (outlined in blue). Navigate to the computer Desktop, and choose the file called "MathisMountCorrection.ppc".
12. The red line in the top box of the PEC Control window will now look vaguely like a sine wave. This means the model has been read from the file.
13. Now click on the *Send PEC Table From File Buff to Controlle* button on the left (circled in red).
14. Keep an eye on the progress, and once this has finished, click the red X in the top right to close the window.

Fig. 8 - PEC Control Window



15. Open MaxIm DL by double-clicking the *MaxIm DL 5* icon on the desktop.
16. Pull up the Camera Control window by going to the *View* menu and choosing *Camera Control Window.*
17. In the Camera Control window under the *Camera 1* heading make sure it reads *Apogee USB/Net* and *Apogee.* If it does, go to 18. If not, first click the *Setup Camera* button and select *Apogee USB/Net* from the *Camera Model* pull down menu. Click *OK*. Next click the *Setup Filter* button. Select *Apogee* from the *Filter or Controlling Camera Model* pull down menu. Click *OK.*
18. Click the *Connect* button (Fig. 9)
19. Click the *Cooler* button under the "Camera 1" heading (red ellipse in Fig. 10). Put the setpoint to -20 degrees C then click *OK*.
    NOTE: for the time being, put the cooler setpoint at +5 C instead
20. Click the *On* button under the *Coolers* heading (dashed blue ellipse) **NOTE:** Once the coolers turn on, you will see the power level being used, the sensor temperature, and the setpoint temperature (Fig. 9 red box). Keep an eye on the cooler power to be sure that it never maintains over 80% power while you are taking exposures, as it introduces artifacts into the images. The cooler will work hard at the beginning of the night, but should stabilize within 10-20 minutes. If it is especially warm out and the cooler power is very high for a longer time, click the *Cooler* button again and raise the setpoint accordingly (-15 C, for example) so the cooler doesn't have to work so hard.
16. Click on the *Expose* tab at the top left.
17. Click the *Options* arrow button and make sure that "No Calibration" is selected (Fig. 11 rectangle).

Fig. 9 - Camera Control window: Setup tab

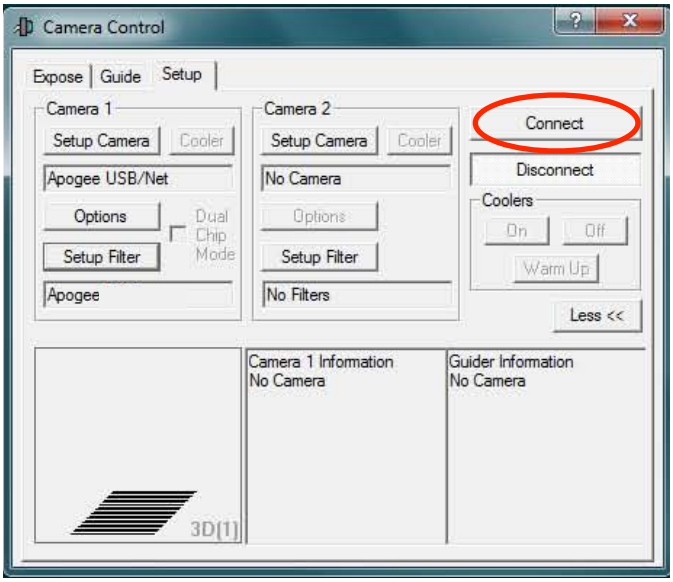
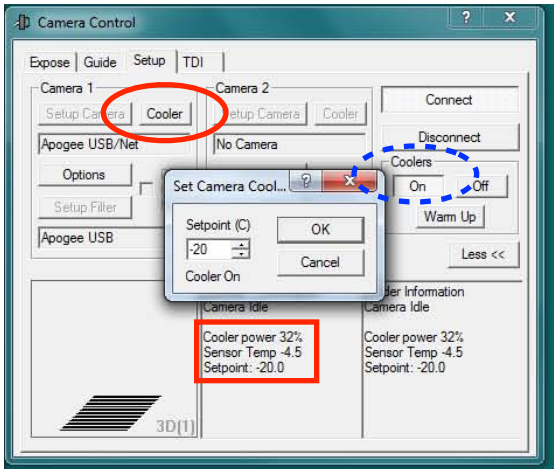
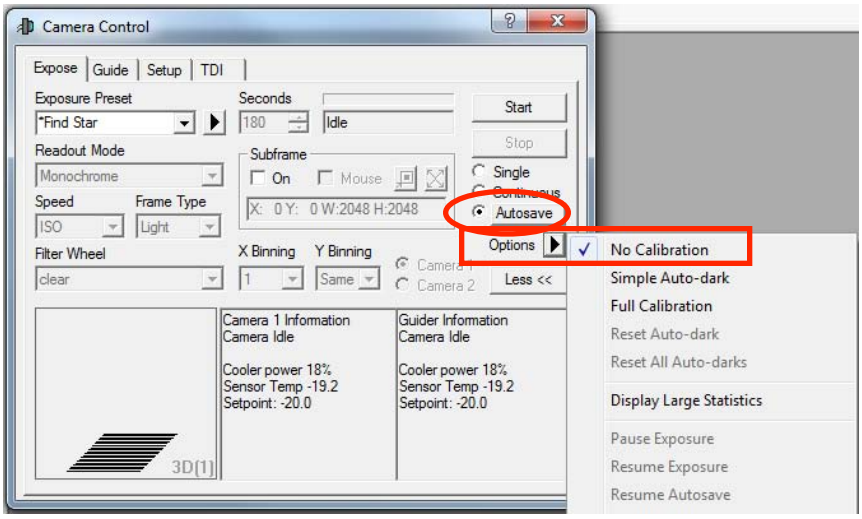


Fig. 10 - Camera Control window: cooler info



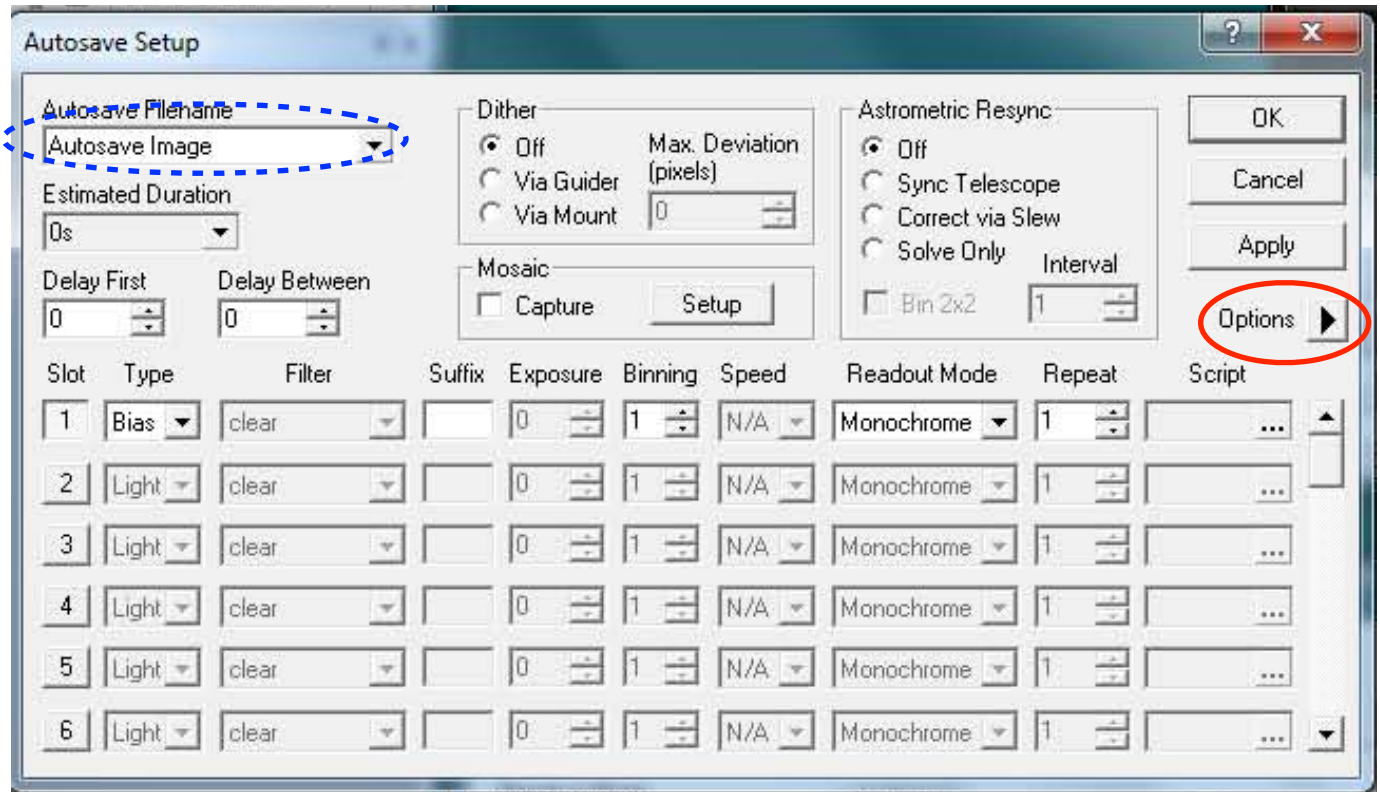
*** NOTE -- It is best to start saving all of your images right away. You can always delete the ones that don't turn out later, that's what logsheets are for. Just note the bad ones as "test exposure" or "junk" so you remember to delete them later.

Fig. 11 - Camera Control window: Expose Tab



18. Throughout the night, keep an eye on the "On" checkbox under "Subframe" in the center of the Camera Control window. It should always be unchecked. If this box gets checked accidentally, you will notice that your frames will seem to read out with no delay (it should take time to read out the chip), and the display will seem odd (zero counts, or just one or two stars when you expect many, etc).
19. Click on the *Autosave* button on the right (circled in Fig. 11).

Fig. 12 - Autosave Setup window



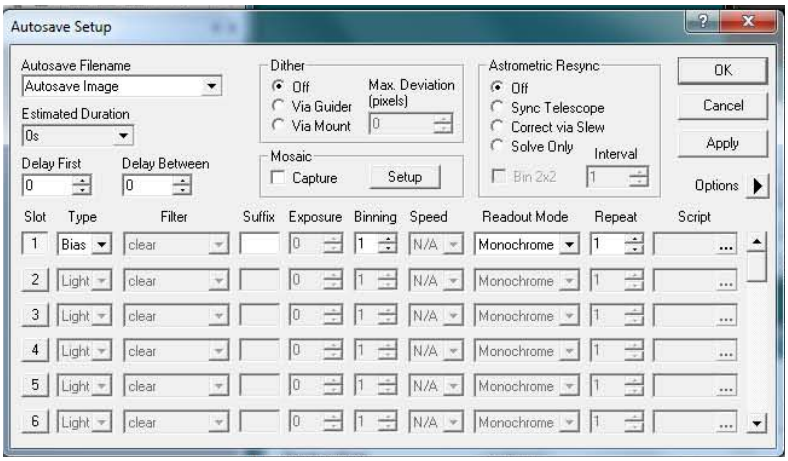
20. In the Autosave Setup window (Fig. 12), click on the *Options* arrow (red ellipse) and choose *Set Image Save Path* to set the path where you will save your data. For ASTR4100/6100, make a new folder named with the calendar date at the beginning of the night (e.g., feb04) in the existing path:
    C:\Users\HLCO\Desktop\A4100_6100\sp2018

21. Once the path is set, you will need to set the root filename for the night's images in the *Autosave Filename* box (Fig. 12 dashed blue ellipse). Just type in the root filename you want to use. Something simple like "feb07" or "may19" is preferred, although others like to name their files with descriptive titles ("object1" or "standard3"). The file names will automatically increment upwards through the night, for example: feb07-001.fits, feb07-002.fits, etc. If you want to take a series of images with different setups or filters, you will need to set several slots in the Autosave Setup window. MaxImDL will then expect you (and will prompt you if you forget) for suffixes ("_bias" and "_dark", for example, or "_B" for filter B, "_V" for filter V, and "_R" for filter R).

You are now ready to take your calibration frames!

Calibration Frames

Fig. 13 - Autosave Setup window - bias frames



1. In the Autosave Setup window (Fig. 13), in the first slot choose "bias" from the drop-down menu. The rest of the settings will pre-fill. Set *Repeat* = 1 (the number of exposures) to start with and hit the *Apply* button in the Autosave Setup window to save your settings (clicking *OK* instead will close the window and you'll just have to open it over and over).
2. In the Camera Control window *Expose* tab, click *Start* to take a bias frame. Zoom the image that appears in the MaxIm DL Pro 5 window to 33% so that it fits nicely on the screen (you will have to type "33" in the zoom box, circled in Fig. 14).

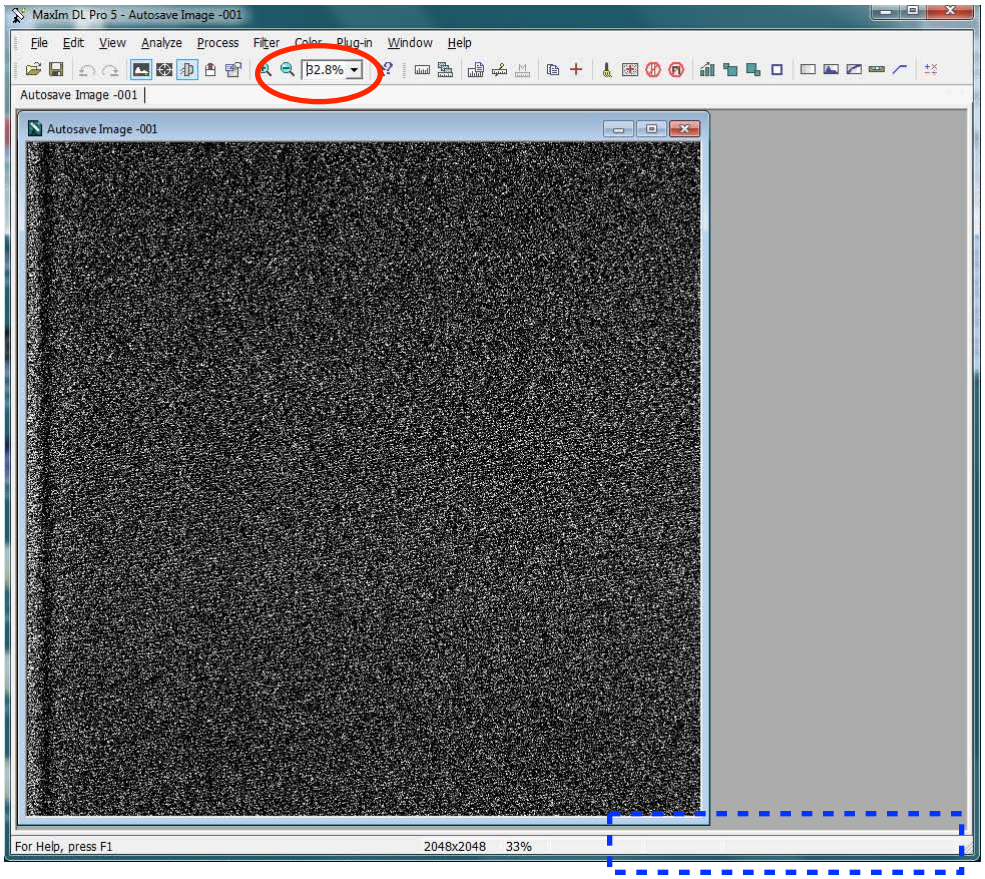


Fig. 14 - Example bias frame

The dark stripe near the left edge is typical of biases taken with this detector.

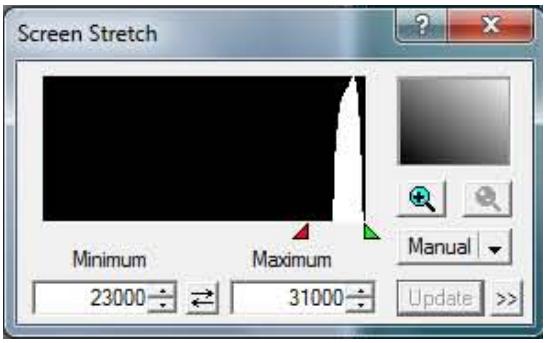
The median number of counts in a typical bias for this camera is ~1100. To check the level of counts, move the cursor around in the image and look at the number on the bottom right of the MaxIm DL Pro 5 window where it says "i: NNNNN" (approximate location of blue dashed rectangle)

3. Assuming all is well and looks like the picture above, set the number of repeats in the Autosave Setup window to "9" or however many additional biases you intend to take. Click *Apply*, and in Camera Control click *Start*. Mark them on your logsheet.

4. Dome flats should be taken with the dome **closed** if the sky is not dark so that you can control the lighting level inside the dome. For dome flats, move the telescope with the hand paddle so that it is pointing at the dome flat screen (canvas) attached to the side of the dome.
5. Plug in the telescope ring light power supply (should be sitting on the telescope base). Turn off the dome lights and the floor lamp. You should see a blue-ish light emitted from the top of the telescope.
6. Take a single exposure in the R filter. Do this by going to the Autosave Setup window. In *Slot 1* change the following: *Type* = "flat", *Filter* = "R". Type the exposure time in seconds in *Exposure,* and *Repeat* = "1". Hit *Apply*, then *Start* in the Camera Control window.

   NOTE: The goal is to get 20,000-30,000 counts in each exposure. If it is still light outside, typical exposure times will be something like B=30s, V=60s, R=60s, but be sure to check the counts.
7. When the image has read out to the screen, set the *Screen Stretch* (display settings, Fig. 15) to have values of -3000 and +3000 counts centered around the median value of the pixels in the center of the CCD (example: median counts ~ 25000, set stretch from 22000 to 28000). Click *Update*. If the *Screen Stretch* window is hidden, open it by going to *View -> Screen Stretch Window.* If you have the right number of counts, you will see a well-illuminated CCD with dust donuts such as Fig. 16.

Fig. 15 - Screen Stretch window



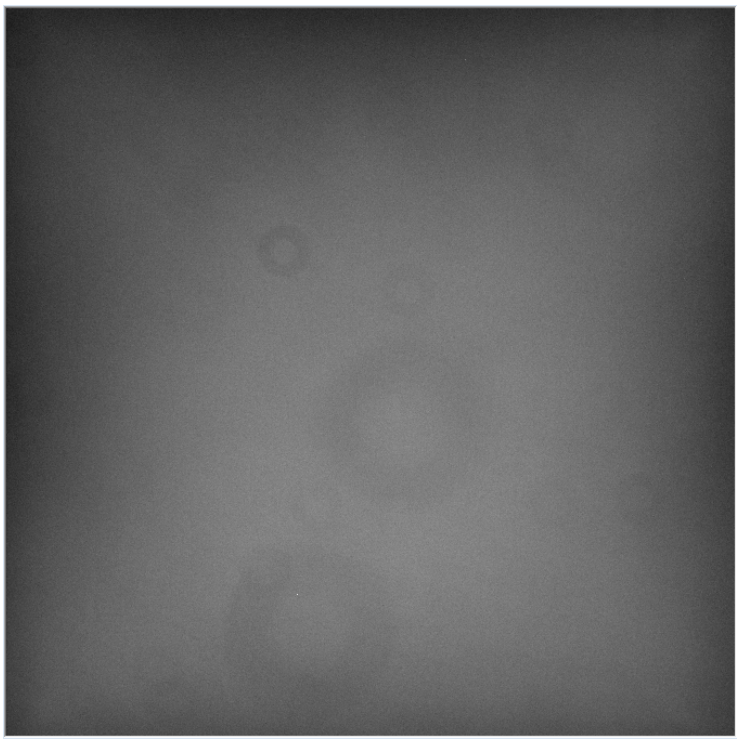


Fig. 16 - Example Rc flat

The slightly darker rings in the frame are dust "donuts" caused by dust particles on the primary mirror of the telescope and are typical features often seen in flats taken at any observatory. Dust donuts are most obvious in Rc flats with this equipment.

The donuts will appear in your science frames as well, and the flats will help you remove them.

If you are seeing counts around 65000, you have saturated the chip. The preview image may appear all black or all white if saturated.

B and V flats may show a lattice structure in the background, which is normal.

8. Adjust the exposure time as necessary (this may take a few tries) and when you have found a good combination, mark all the test exposures in your logsheet and set up the number of repeats in the Autosave Window to the number needed to complete the flats for that filter.
9. Change the filter, adjust the exposure time, take a test image, and repeat as necessary until all your flats are finished, then **unplug the ring lights**. Make frequent notes in the logsheet so it will be easy for you to remember which images were your tests and which were your good flats.
10. If you wish to take sky flats, follow these guidelines:
    - don't bother with sky flats unless the sky is clear, patchy clouds will make your sky flats worthless
    - point the telescope 180 degrees opposite the sun (east in the evening, over the floor lamp) at an elevation of ~45-60 degrees
    - start your flats with the bluest filter first and progress through to reddest filter last (opposite for dawn flats)
    - beginning about 15-20 minutes after sunset, start taking test flats and checking the counts on readout; you still want to aim for >2 sec and 20,000-40,000 counts
    - once you hit the right lighting level, take flats as quickly as possible, adjusting the exposure time and/or the filter as needed to stay within your goals as the light gradually fades away
    - you should be familiar with the equipment and software before attempting sky flats -- they can only be carried out during a short window of time at dusk
11. When you are ready to carry out your darks, choose *Type =* "dark" and set the exposure time to the appropriate value to match your science observations. An example dark frame is shown in Fig. 17.

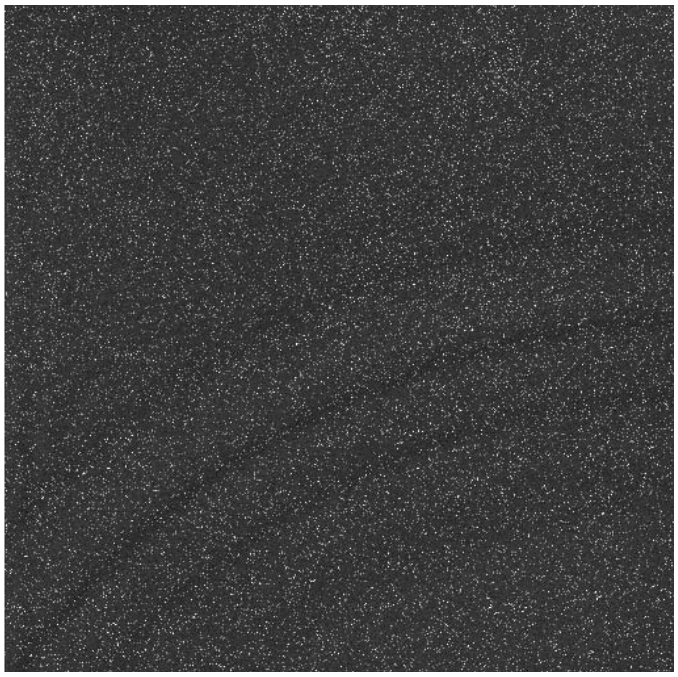


Fig. 17 - Example dark frame

The bright pixels are somewhat hotter than the others and collect dark current more quickly than the average pixel.

The arcs or streaks across the bottom half are a "feature" of the old detector (new example image needed here).

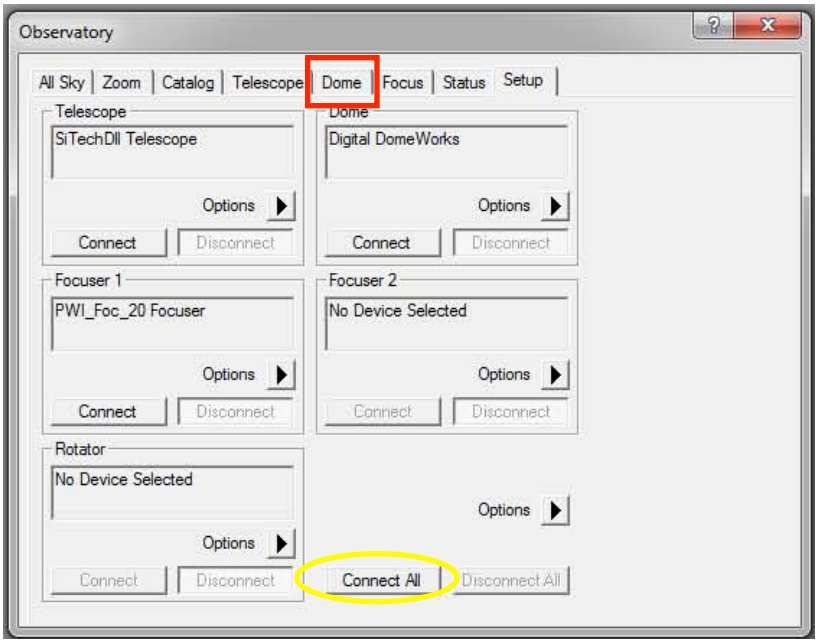
You are now ready to observe on the sky!

Pointing and Alignment

1. If you took opened the mirror covers for dome flats and the dome is still closed, it is always a good idea to *close the mirror covers* before opening the dome so that nothing falls off the top of the dome and lands on the mirrors. Just remember to open the covers again after the dome has finished opening.
2. At this point in the evening, you are observing on-sky and it's important to remember a few things:
   - TURN OFF THE DOME AND RING LIGHTS! We want light from celestial objects, not manmade ones.
   - Make sure all the outside lighting is off. **Take a key with you so you don't get locked out of the building. Better yet, always have your key attached to your person.** Walk around outside to be sure there aren't any lights on. Most of the light switches are by the front door.
   - Turn off all of the bright lights in the building (the window shades aren't very good). Turn on some red lights in the hallways so you can walk around if you need to.
   - On a similar note, any and all computer monitors, cell phones, etc, should be turned off or covered up before beginning any exposures.
   - Take care to avoid stray light from the hallway -- keep the dome door closed when exposures are in progress. Be aware of what is happening with your exposures and when it is okay for you to go in and out of the door.

3. In MaxImDL, open the Observatory Control window by going to the *View* menu and choosing *Observatory Control Window.* Make sure it opens on the *Setup* tab (Fig. 18).

Fig. 18 - Observatory Control window - Setup tab



4. Check that the boxes are filled in as shown. Click *Connect All* (Fig. 17 yellow ellipse.)

5. Click on the *Dome* tab at the top of the Observatory Control window (red box, Fig. 18). Turn on dome tracking by checking the box circled by the red ellipse in Fig. 19.
6. Now click on the *Telescope* tab at the top of the Observatory Control window (Fig. 20). You should see that the telescope is connected and showing the RA and Dec position for its current pointing. You should also see that the telescope is not tracking (red ellipse).

7. Turn on tracking by clicking in the small box to the left of “Sidereal Tracking” (Fig. 20 red box). The telescope is now tracking the apparent motion of the celestial sphere due to the Earth’s rotation. The message in the box at the top will change to reflect this.
8. Now you need to find a bright star to check the pointing of the telescope and make any small adjustments. You will do this with TheSky to make your life easier. Open TheSky program by double-clicking on *TheSky6* icon on the desktop. *Note:* Make sure the window that opens (Fig. 21) is not maximized to fill the whole screen because you will need to be able to access your other windows. Take the time to arrange them now.
9. Establish a link between TheSky and the telescope by going to the *Telescope* menu (red ellipse in Fig. 21) and choosing *Link* -> Establish. This will cause a white target to appear. The white target indicates where the telescope is currently pointing.
10. In the star map display in TheSky window, click on a bright star (big spot, may be whitish, blueish, or reddish to approximate the color of the star) near the middle of the star map. A bigger spot is a brighter star, and the middle of the map shows objects near the zenith. A popup window will give you information on the object you have selected, including magnitude (look for something very bright, 0mag or 1mag) and the altitude and airmass (so you know if it is safe to slew to that target).

Fig. 19 - Observatory Control window - Dome tab

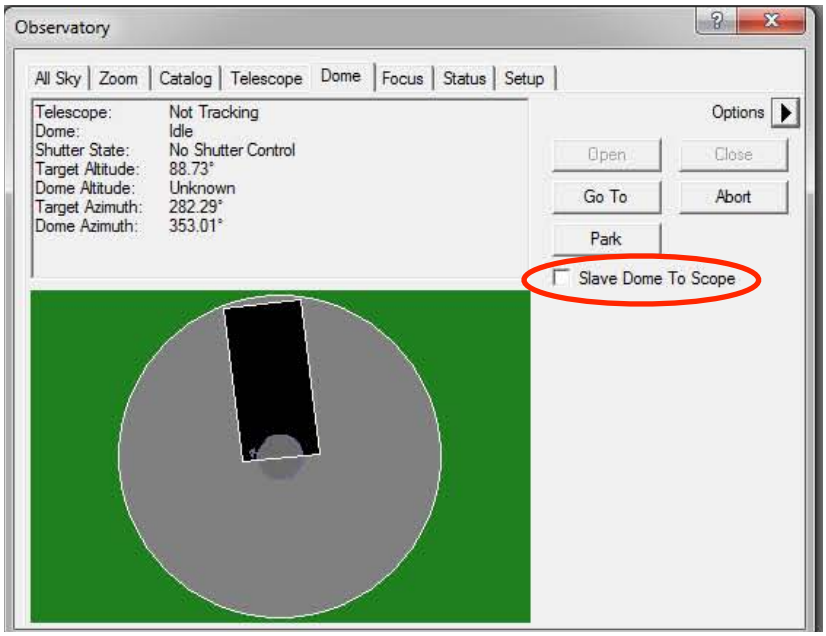
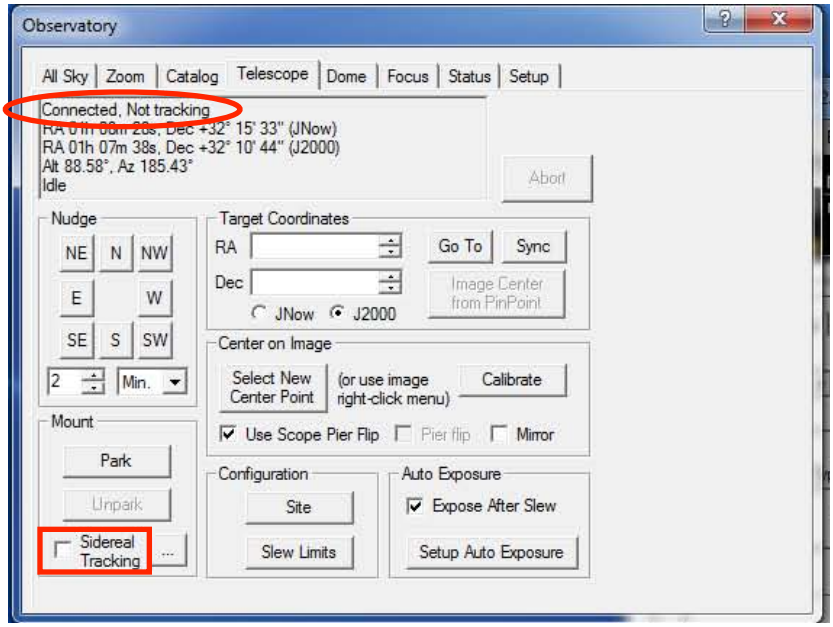


Fig. 20 - Observatory Control window - Telescope tab



**** WARNING ****

Remember that the telescope has few safety limits. It is up to you to verify that the position of the star will not endanger the telescope. Double-check the altitude and the airmass to be sure that you won’t point at the floor!

Remind yourself where the **STOP** button is and **ALWAYS ALWAYS ALWAYS** watch the telescope when it is moving. Be ready to hit **STOP** at any moment.

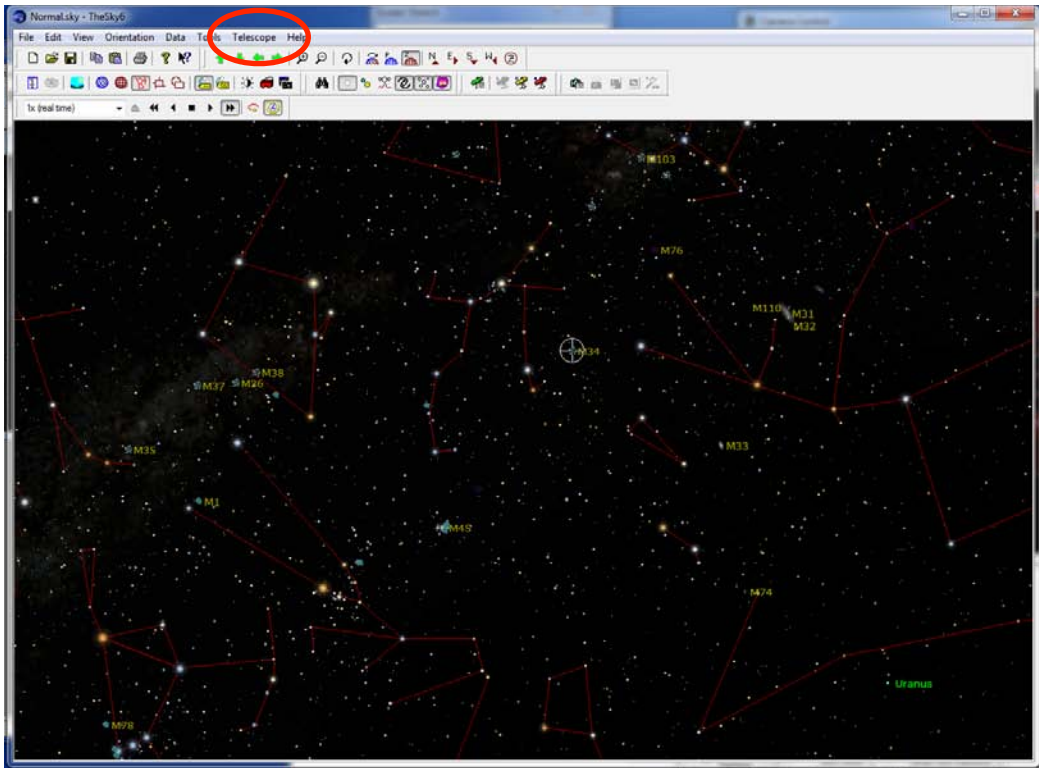


Fig. 21 - TheSky star map window

11. Once you have verified that your current selection is a safe choice, click the small green telescope icon at the bottom of TheSky popup information window  and confirm that you wish to slew the telescope to that object. **WATCH THE TELESCOPE AS IT SLEWS - SHINE A FLASHLIGHT ON IT IF NECESSARY.**
12. As the telescope slews, the dome will follow along. It will beep before moving, and it may pause to check the telescope progress partway through its rotation. Wait for both the dome and the telescope to finish moving.
13. Take a quick image to be sure that the star is in the field of view --- in the MaxIm DL Autosave Setup window, change the "Type" to *Light* and set up a short (0.2sec) exposure in V to see where the star appears on the CCD. Take the image.

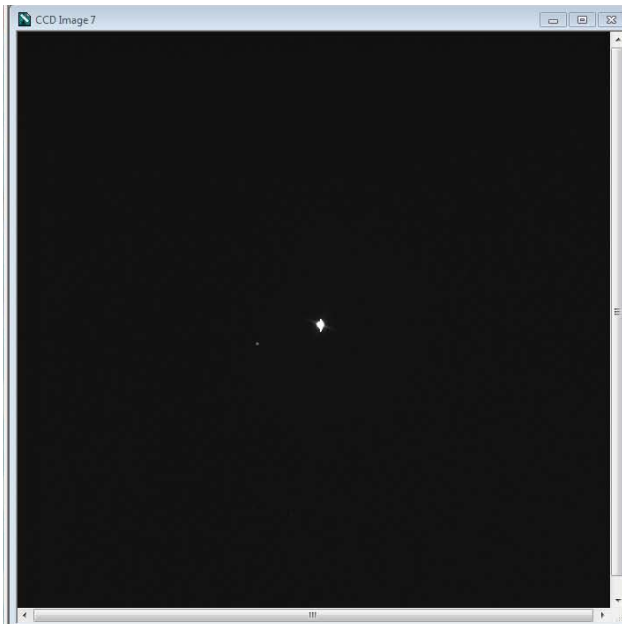


Fig. 22 - Saturated Regulus

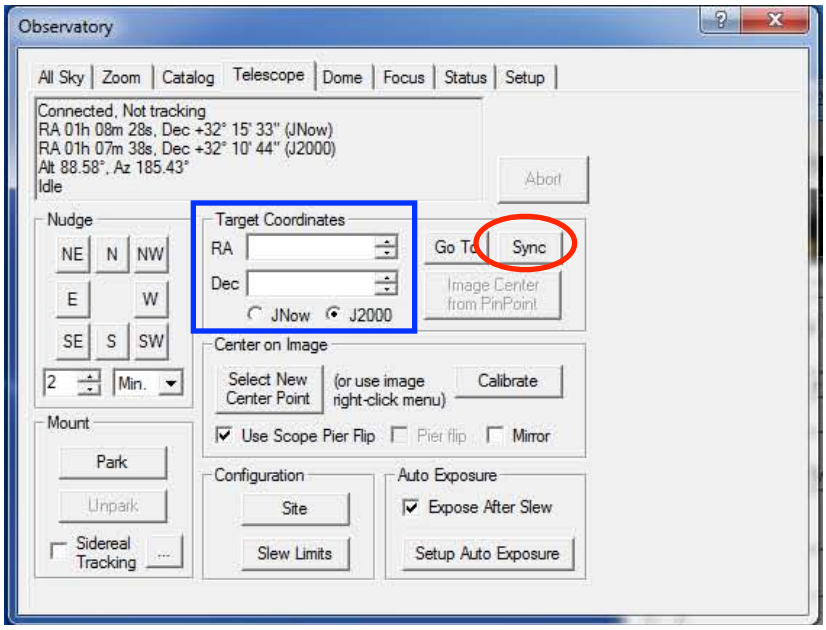
Very short (0.2 sec) exposure of Regulus (α Leo) on a clear night, m(V) = +1.35

Note the bleeding from the saturated pixels, even with such a short exposure.

14. Use the movement hand paddle to put the target star where you want it in the frame. The arrows on the paddle will move the star the direction you want -- click the “left” arrow to move the star left in the resultant CCD image. This is best done with the speed set to *pan* (yellow LED lit up on the black box on the back of the telescope pier). One click will move the target about 10-20% of the distance across the chip. Take another short exposure. Repeat this process until you have the star positioned appropriately.
15. In the MaxImDL Observatory Control window, enter the RA and Dec coordinates of the star you are currently pointing at. Be sure they are J2000 coordinates and that the J2000 button is selected (Fig. 23 blue box). Then click the button labeled “sync” to save your pointing adjustments (Fig. 23 red ellipse).
16. Check that the pointing is set properly by doing the following:
    - choose another bright star from TheSky and click to open the popup window
    - check its magnitude to be sure it is bright (and will be obvious in any images)
    - check its altitude and azimuth to be sure that it is safe to slew
    - enter the J2000 RA and Dec coordinates for the star in the MaxImDL Observatory Control window (Fig. 23)
    - be sure the J2000 button is selected
    - click “Go To” to begin slewing to the bright star
    - take a quick image to be sure that the star is in the frame and roughly where you would like it to be positioned

16. If at any time the pointing is lost and you cannot directly slew to a bright star, the first task is to re-home the telescope using the STI window and the Homing Operations window (refer to Troubleshooting). In the STI window, click *Prk* to park the telescope. Then click *UnPrk* to unpark it. Then try to slew to a bright star with TheSky and take a quick image to see if it is there.

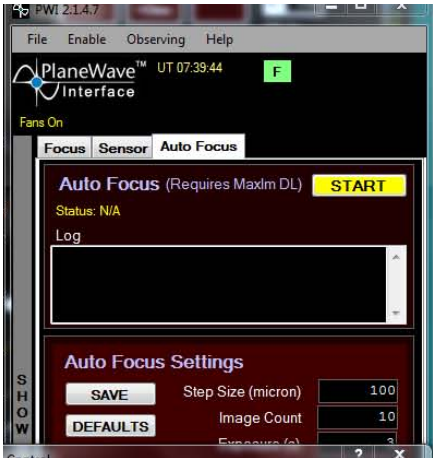
Fig. 23 - MaxImDL Observatory Control window



Digital Focusing Procedure ***-- Currently not working, use manual focusing procedure***

1. We suggest using autofocus, however, you can manually focus the image using the hand paddle attached to the back of the primary mirror. It will have illuminated orange buttons. The only two buttons that function are the up and down arrows. Use these buttons to adjust the focus to the desired position if you so desire.
2. To use the autofocus routine, you will use the *Planewave Interface* window that should have popped up when you chose "Connect All" in the MaxImDL Observatory Control window. For good measure, click "Connect" in this window (lately MaxImDL has been saying it is connected but it actually isn't).
3. Use *TheSky* to point the telescope to a field with a good number of bright stars such as an open or globular cluster. The rich open cluster M37 is a good choice for the beginning of the night in February. Click on M37 in *TheSky* window, carefully check its current position (altitude, airmass, etc), and then click the small green telescope icon  to slew to it if everything looks ok.
4. In MaxImDL, take some test exposures to find an exposure time (~15 seconds or so) which yields decent signal-to-noise on a fair number of stars. A recommendation is 500 to 1000 counts above the background level for several stars.
5. When you have determined a useful exposure time, click the *Auto Focus* tab in the Planewave Interface window (Fig. 24).
6. Keep the step size and image count at their defaults (100micron & 10 respectively) and input the exposure time identified in step 4
7. Remember to turn off or cover up the computer monitor (s) before clicking *START* to begin the autofocus routine. The program will step through 10 exposures (each with the exposure time you specified) as it changes and tests the focus.
8. Log the adopted focus value in your logsheet along with the current temperature (from the HLCO weather web page). Add any other weather information to the logsheet now (clouds, wind, etc).
9. If the monitor is covered up and you can check the screen, two windows will appear once the first image is taken: PlateSolve 2.0 & Focus Analysis.
10. Click *keep open* in the PlateSolve window to allow you to investigate focus.
11. Click s*how graph* in the Focus Analysis window to show Spot Diam. vs. Focus Position.

Fig. 24 - Planewave Interface



Note: If Auto-Focus fails, this is usually because the starting focus values was too far away from the best focus. Increase the step size and run again. Once a rough solution is found, rerun the Auto-Focus using the smaller step size to ensure a more precise focus.

12. When you have finished focusing, double check that the subframe box is not selected in the MaxImDL Camera Control window. If it is, de-select the checkbox.

Manual Focusing Procedure

1. We suggest using autofocus, however, you can manually focus the image using the hand paddle attached to the back of the primary mirror.
2. Use *TheSky* to point the telescope to a field with a good number of bright stars such as an open or globular cluster. The rich open cluster M37 is a good choice for the beginning of the night in February. Click on M37 in *TheSky* window, carefully check its current position (altitude, airmass, etc), and then click the small green telescope icon  to slew to it if everything looks ok.
3. In MaxImDL, select the filter that you will take the majority of your observations through, or the middle filter if you will be using several (usually V is a good choice). Take a few test exposures to find an exposure time (~5-10 seconds or so) which yields decent signal-to-noise on a fair number of stars. A recommendation is for several stars to have 500 to 1000 counts above the background level.
4. Press the Up button on the focus hand paddle for half a second. Take another exposure in the V filter. Does the image look any better? A good focus has the stars looking as small and sharp and round as possible.
5. Repeat step 4 until the image begins to look noticeably worse.
6. Now press the Down button for half a second and take an exposure. The image should improve.
7. Repeat step 7 as the image improves, until it begins to worsen.
8. Press the Up button 2-3 times to put the focus back in the good range and take an exposure to check the image quality. Adjust as necessary.
9. Keep an eye on the focus of your images throughout the night. As the temperature changes, you may need to adjust the focus again.

Science Frames

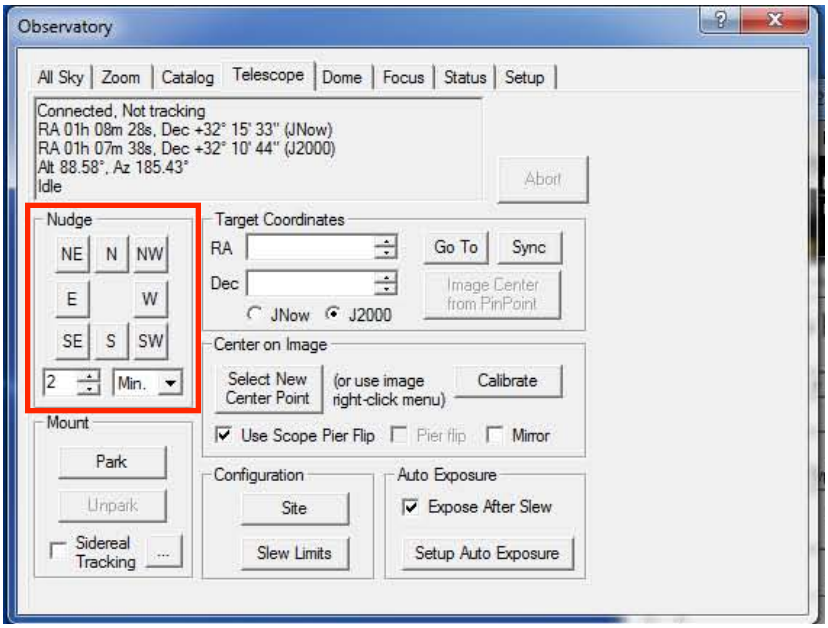
Hooray! Now that your calibrations are finished and the telescope is pointed, guiding, and focused, it's time for your science observations! Use MaxImDL to slew to your targets and carry out your exposures following the procedures outlined above.

The field of view for the camera may not display North up and East left on the computer screen. If the camera has recently been removed from the telescope and then replaced, this can change. Plan to spend some time with your finder charts to be sure you know where your object is and how it appears on the computer screen.

There is a bad column just off the center of the detector which can affect your measurements. Plan to center your object so that is not affected by this column.

Always aim for at least a few 1000 counts in your science target above the background level (but less than ~50,000). Take a test exposure to determine the number of counts you are getting in a certain amount of time. If you saturate, take a shorter test exposure. If you can't find your object, take a longer exposure. Be sure to check the number of counts in **each filter**.

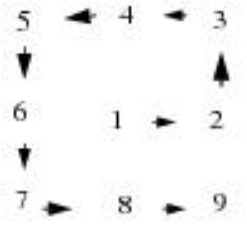
Fig. 25 - Observatory Control window - Nudge



Remember to dither between images. You can use the "Nudge" buttons in the MaximDL Observatory Control window under the Telescope tab (Fig. 25, red rectangle).

2-3 arcmin nudges are plenty large enough. The goal of dithering is to move all the sources in the field so that they fall on the detector a few pixels away from their previous location, but dithers must be small to ensure that everything stays in the field of view.

A good plan might be to dither your images around the center in a spiral pattern (example to the right), with each number showing the location where an image would be taken.



Don't forget to take dark frames. Even though the camera shutter will not open, keep the dome lights off in case of light leaks. Dark frames should have the same "exposure" times as your science frames and *Type* = "dark". You can take these at the end of the night after your exposure times have been settled.

Remote Observing in the Electronics Room

Remote observing is now possible in the electronics room. Be sure to double-check the following items before leaving the dome:

1. telescope tracking is turned on and working
2. dome tracking is turned on and working
3. ladder in dome is against the wall, away from the telescope
4. computer monitor in dome is turned off

IMPORTANT: **All telescope slewing should still be carried out in the dome, but long sets of exposures can be set up and carried out in the electronics room with small pointing adjustments and dithers**

Use the Mac on the desk in the electronics room to observe remotely. **DO NOT** use the windows computer running the all sky camera and the weather station.

Open “Screen Sharing” on the Mac from the app bar at the bottom of the screen. Go to Connection -> Open Recent -> hlco-pc-1
The password is saved and you should be connected right away.

The screen should now show the desktop for the dome computer, just as you left it moments ago.

There are video cameras mounted in the dome that are sensitive to both visible and infrared light, and the camera feeds should be displayed in one of the monitors mounted to the wall. On the Mac, open Safari and choose the bookmarked link titled “Live Video - Miller Webcams”. The page will prompt you for a username and password twice. The username is “hlco” and password is empty for both cameras. Once they are running, drag the Safari browser up the screen to the monitor on the wall and KEEP AN EYE ON THEM!

You can close the Safari browser to stop the webcam feed at the end of the night. If you leave it up, it may lock up the computer and require a restart, but that is easily done if necessary.

On the other monitor, you should see the weather webpage for the observatory and a radar map. Pop-up rain storms can occur with very little notice, so if the humidity is high, keep a very close eye on the radar map. Be sure to check this monitor frequently as well.

Remember to **go to the dome to carry out any large slews**, then come back for the observations. You can use the “nudge” buttons in the MaximDL Observatory Control window to dither between science frames or make small pointing adjustments. A few (2-4) arcmin dithers should be plenty large enough.

Shutdown Procedure

1. Close the Planewave Interface by clicking the red *X* button at the top right.
2. Begin closing down MaxIm DL using the following procedure:
   (a) Click the *Setup* tab in the Camera Control window
   (b) Click the *Warm Up* button under the *Coolers* heading.
   (c) Unclick "Sidereal Tracking" in the Observatory Control window.
   (d) In the Observatory Control window, under the "Dome" tab, click "Park" to home the dome. When the dome has finished moving, go to Step (e).
   (e) In the Observatory Control window under the "Setup" tab, click "Disconnect All". The dome may beep at you shortly after this step -- that is normal.

Note: DO NOT simply turn off the coolers without going through the warming up phase. The camera is thermoelectrically cooled and a rapid change in temperature could cause the chip to crack...that would be bad.

3. Allow the camera to warm up while you do the following steps.
4. Disconnect the link between the telescope and TheSky through the *Telescope* menu (in the TheSky program) and choosing *Link -> Terminate*.
5. Exit TheSky without saving changes.
6. Close the mirror covers and replace the baffle cover (shower cap).
7. In the STI window, make sure that *UnPrk* is selected. If not, click it (this may turn on tracking -- if so, click *Off*). Choose *Park* under the *Scope* side tab. Watch the telescope to be sure that it parks itself pointing at the zenith. If it has lost the park position, stop the telescope, rehome, and then re-park.
8. Exit the STI program by clicking the X button at the top right.
9. Close the lower dome shutter with the rocker switch. It will automatically stop when it is fully closed.
10. Close the upper dome shutter with the two switches to the right **ONLY AFTER THE LOWER SHUTTER IS COMPLETELY CLOSED.**
11. Put a copy of your logsheet in the folder on the HLCO computer with your data for safekeeping.
12. Copy your data onto a USB thumb drive to take home.
13. Check the temperature on the CCD camera in the Camera Control window. You may finish shutting down the camera if the *Sensor Temp* has risen to -10 C or more (if not, give it another few minutes to warm up some more). To finish closing it down:
    - click "Off" underneath *Coolers* to turn off the coolers
    - click the *Disconnect* button
    - click the *X* button to close the main program.
14. Leave the dome computer on, but check that all programs have stopped & closed.
15. Turn off the power strip on the side of the telescope and the black box on the back of the pier.
16. Unplug the power cords from the plug at the base of the pier.
17. Close the windows in the dome if you opened them.
18. Gather your things and be sure to turn off the lights when you leave.
19. Drive home safely and watch for deer!

TROUBLESHOOTING

The dome won't connect in MaximDL:
Check that the switches on the blue boxes on the wall by the circuit breaker panel (near the door) are turned to "On". If not, turn them "On" and leave them like that when you go home.

The dome won't connect in MaximDL and/or the camera cooler isn't updating (and other software issues):
Restart the computer.

My object is not showing up in the image:
1. Is the image saturated? (~65000 counts all over, may show up as a completely black image)
2. Have you zoomed the image display to an appropriate size so you can see the whole image?
3. Is the "On" checkbox under "Subframe" in the Camera Control window Expose Tab unchecked? (Fig. 10)
4. Did you open the mirror covers?
5. Is the dome slit rotated to match the direction the telescope is pointing?
6. Did you turn off the dome lights and the computer monitor?
7. Is the camera power cable connected?
8. Is it cloudy?
9. Have you checked the telescope pointing with a bright star?

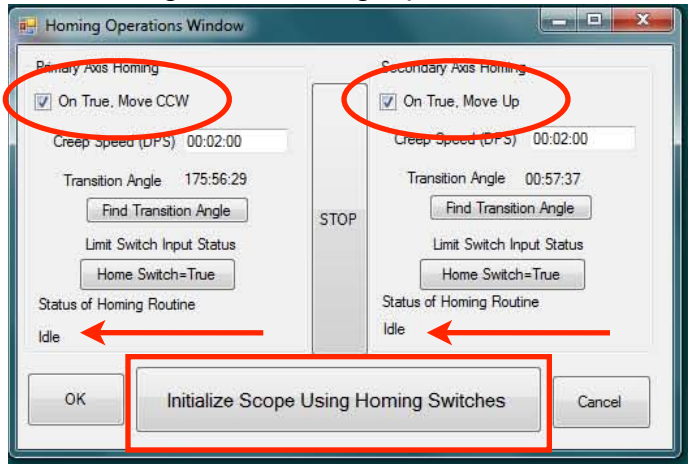
If 1-8 are not the solution and you have lost pointing of the telescope, you will need to reset the pointing solution following the steps below.

The telescope seems to have lost pointing:
If the telescope pointing is off and the desired target is not well centered after a slew, or not even in the frame, the pointing model may require an update.

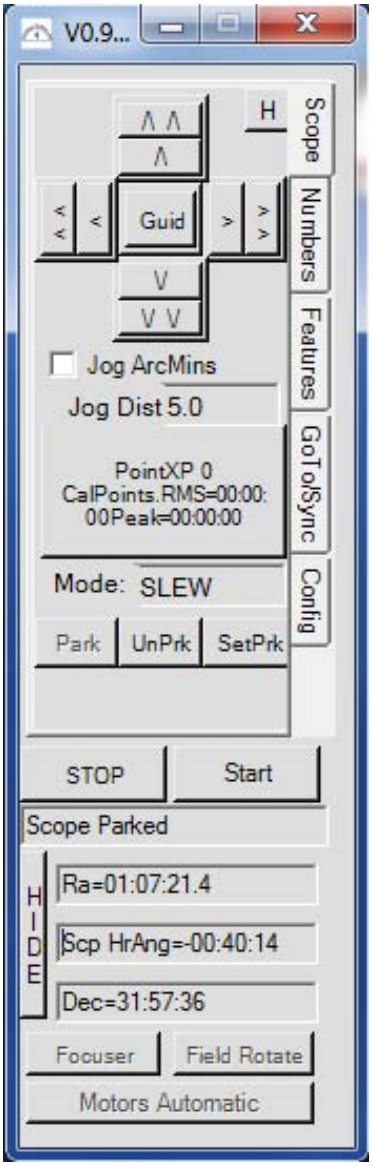
1. Be sure that *UnPrk* is chosen in the STI window under the *Scope* side tab. If *Park* is chosen, click *UnPrk*. This may cause the telescope to begin tracking. If so, click the *STOP* button.
2. Choose *Features* from the tabs along the right side of the STI window. Click the "Home" button.
   - This will cause the Homing Operations window to appear.
   - Make sure both checkboxes are checked (red ellipses in Fig. 6). These boxes should always be checked
   - Click the *Initialize Scope Using Homing Switches* button (red box in Fig. 7).

- Make sure the *Status of Homing Routine* on both sides of the *Stop* button read *Idle* (red arrows in Fig. 26) before moving on and pressing *OK* to close the Homing Operations window.

Fig. 26 - Homing Operations window



3. In the STI window under the *Features* side tab, click the *Home* button. Make sure both of the checkboxes are checked at the top of the Homing Operations window, then click *Initialize Scope Using Homing Switches*. Make sure the telescope goes to its home position (see picture at beginning of manual). Be ready to click **STOP** if it tries to go somewhere else. Wait for *Idle* to show on both sides of the window before proceeding.
4. In the STI window under the *Scope* side tab, click the *Park* button to park the telescope.
5. After the telescope has parked, click the *UnPrk* button to unpark the telescope.
6. Try to slew to a bright star with TheSky and take a quick image to see if it is there. Pick something really obvious, like a 0mag star that is easily seen with the eye through the dome shutter opening.
7. If the pointing is really lost, use the finder scope on the side of the telescope tube and the hand paddle to center the bright star in the field of view of the eyepiece.
8. Take a quick image with MaxImDL and adjust the positioning of the star in the CCD frame with the hand paddle.
9. When you are satisfied, put the J2000 coordinates in the Observatory Control window of MaxImDL, make sure “J2000” is chosen rather than “JNow”, and click the “sync” button.
10. Test your new pointing solution by slewing to a new bright star (using TheSky or typing the coordinates into MaxImDL). It should appear in your field of view now.



The dome seems to have gotten lost:

1. In the MaxImDL Observatory Control window, under the *Dome* tab, uncheck “Slave Dome to Scope”.
2. Press the “park” button to send the dome to its home location.
3. Reconnect the dome to the telescope’s pointing by checking “Slave Dome to Scope”.

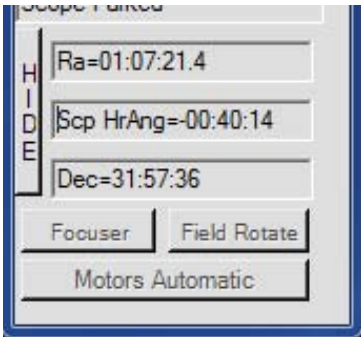
The telescope seems to have forgotten its Park location:
The telescope sometimes loses its Park location, but this can often be recovered by homing the telescope. Sometimes homing the scope twice will solve this issue. Follow the steps below in order until the problem is solved (no need to go through all the steps if it is solved early in the process).

1. Be sure that *UnPrk* is chosen in the STI window under the *Scope* side tab. If *Park* is chosen, click *UnPrk*. This may cause the telescope to begin tracking. If so, click the *STOP* button.
2. In the STI window under the *Features* side tab, click the *Home* button. Make sure both of the checkboxes are checked at the top of the Homing Operations window, then click *Initialize Scope Using Homing Switches*. Make sure the telescope goes to its home position (see picture at beginning of manual). Be ready to click **STOP** if it tries to go somewhere else. Wait for *Idle* to show on both sides of the window before proceeding.
3. In the STI window, choose *Park* under the *Scope* side tab. Watch the telescope to be sure that it parks itself pointing at the zenith. If it goes elsewhere, stop it.
4. Try homing the telescope again as in steps 1 and 2. Do step 2 twice in a row.
5. Try parking the telescope (step 3). Be ready to stop it again if necessary.
6. Home the telescope one last time.
7. Use the hand paddle to point the telescope at the zenith manually. Once there, click the "SetPrk" button in the STI window to reset the Park location.

MaxImDL has frozen up:
This is a new feature and seems to happen when the system is allowed to sit idle for a long period of time, although lately it seems to be getting worse. We are working on getting the computer replaced. For now, follow the steps below whenever you ask MaxImDL to take an exposure and it refuses:

1. Turn off the camera cooler and disconnect the camera in the Camera Control window.
2. If they are connected, disconnect the telescope and the PlaneWave focuser in the Observatory Control window. You may have to individually disconnect them if the "Disconnect All" button is unresponsive.
3. Completely shut down MaxImDL and be sure the program closes. Kill it in the system processes if necessary.
4. Restart MaxImDL.
5. Re-open the Camera Control window and connect the camera and filter wheel.
6. Restart the camera cooler (it will not have had time to warm up appreciably, so there is no need to worry that you will damage the camera if this happens).
7. Re-open the Observatory Control window and "Connect All" to connect the telescope and PlaneWave focuser if you were previously connected to them. Restart sidereal tracking.
8. Take a test bias or quick image to be sure that MaxImDL is now responding. You can now resume where you left off.

The telescope is slewing with a jerking motion, and possibly ended its slew early:
This only seems to happen on very cold nights.



1. In the STI window, at the bottom where it normally says “Motors Automatic”, it will now say “Blinky Motors”.
2. Click the "Blinky Motors" button to unfreeze the telescope.
3. Try slewing again. To prevent the telescope from freezing up, you can slew shorter distances at a time, essentially star-hopping to your target. Using *TheSky* can make this very simple. See how long a slew distance the telescope can handle. This may vary throughout the night.

The computer isn’t talking to the mirror covers
Quite possibly, you opened the *PlaneWave Shutter Control* program, connected to the mirror covers, and then closed the program (breaking the connection). If a computer restart is not an option, or if something else is the problem (perhaps a cable has died or the control box is having other issues), then manual control should still work.

1. Turn the control box on if necessary. (*left picture, below)*.
2. Press the “Manual Drive” red button on the opposite side of the box from the power switch (*right picture, below)*.
3. Once the mirror covers have stopped moving, turn the control box off.

The power has gone out and the dome is open
There is a long pole near the base of the stairs in the short hallway between the dome and the main building. You can hook this pole into the top center of the dome and crank the upper dome shutter closed.